# Comparative Study Of Bonded & Unbonded Post-Tensioning Beams In Building

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## Abstract

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*During the past century, the use of prestressing has increased tremendously. Most important techniques of prestressing is post-tensioning. In post tensioning two different method bonded and unbonded technical. Due to those technical used in tendons/strands, thus overcome the more flexible and fast construction compare to RCC. Bonded and unbonded system in stress, strength, deflection, bending moment and load balancing condition with solve by theoretical and software. System present in graphical and designing data. Both methods applying and solve base on case-study. Also find steel quantity span up to 10-40 meter use for both systems, steel tendons in post-tensioning applications, is described. Final draw the design of bonded and unbonded beam with suitable anchoring location. At results of bonded and unbonded system which is best for minimum losses and construction suitability on given by case study data.*

## 1. Introduction

Pre-stressing of concrete is defined as the application of compressive stresses to concrete members. Those zones of the member ultimately required to carry tensile stresses under working load conditions are given an initial compressive stress before the application of working loads so that the tensile stresses developed by these working loads are balanced by induced compressive strength. Post-tensioning is a method of reinforcing (strengthening) concrete or other materials with high-strength steel strands or bars, typically referred to as tendons. Post-tensioning applications include office and apartment buildings, parking structures, slabs-on ground, bridges, sports stadiums, rock and soil anchors, and water-tanks. In many cases, post-tensioning allows construction, which would otherwise be impossible due to either site constraints or

Post-tensioning is a technique of pre-loading the concrete in a manner which eliminative, or reduces, the tensile stresses that are included by the dead and live loads. Post tensioning is a method of strengthening concrete or other materials with high-strength steel strands, wires or bars. High strength steel ropes, called strands, are arranged to pass through the concrete. When the concrete has hardened, each set of strands is gripped in the jaws of a hydraulic jack and stretched to a pre-determined force. Then the strand is locked in a purpose-made device, called an anchorage, which has been cast in the concrete

Post-tensioning application includes office and apartment buildings, parking structures, slabs- on-ground, bridges, sports stadiums, rock and soil anchors, and water-tanks In many cases, post-tensioning allows construction that would otherwise be impossible due to either site constraints or architectural requirement. Post-tensioning construction is classified as bonded and unbonded, depending on whether the tendon ducts are filled with a mortar grout after stressing (bonded), or whether the tendons are greased and paper wrapped, greased and plastic covered or moisture tight (unbonded). Use of unbonded construction eliminates the time and cost involved in grouting which becomes an important 12 economic factor in applications such as floor slabs of apartment buildings which usually contain a large number of small tendons. In unbonded post-tensioning system tendons remain detached from concrete along their length for the entire life of structure. In grouted (bonded) system tendons are attached to the encasing concrete along their entire length and follow the deformation of concrete

**Bonded And Unbonded**:

Unbonded tendons typically consist of single (mono) strands or threaded bars that remain unbonded to the surrounding concrete throughout their service life - giving them freedom to move locally relative to the structural member. The strands in unbonded mono-strand systems are coated with specially formulated grease with an outer layer of seamless plastic extruded in one continuous operation to provide protection against corrosion. Depending on the application n and the level of protection that is needed, the anchorages of unbonded mono-strand systems may also be encapsulated. Light and flexible, unbonded mono-strand can be easily and rapidly installed - providing an economical solution Bonded post-tensioning systems are comprised of tendons from one to multiple strands (multi strand) or bars. For bonded systems the pre-stressing steel is encased in a corrugated metal or plastic duct. After the tendon is stressed, cementations grout is injected into the duct to bond it to the surrounding concrete. In addition, the grout creates an alkaline environment which Provides corrosion protection for the pre-stressing steel. An advanced duct system, PT-Plus, encases the pre-stressing steel in a corrugated duct and plastic coupler system Bonded strand post-tensioning systems can range from a single strand to 55 or more strands in a single tendon, while the anchorage assembly consists of local zone confinement reinforce me not, bearing plate, anchor head, wedges and grout cap. Bonded multi-strand systems, while used extensively in new construction of bridges and transportation

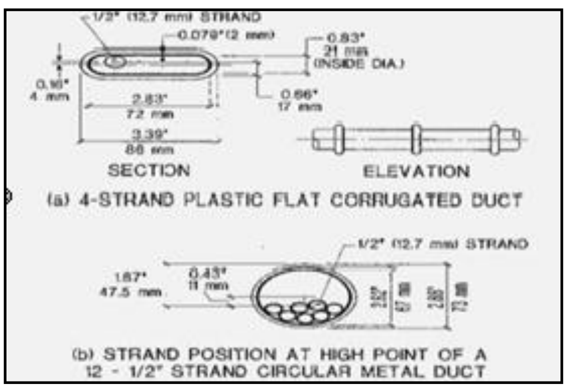


**Figure 1: bonded system tendon detail for beams and slabs**

Structures can be and have been successfully applied to commercial building structures. When these multi-strand systems are used for large structural elements such as beams and transfer girders, design advantages include increased span lengths and load-carrying capacity and reduced deflection. The distinguishing characteristic of an unbounded tendon is that by design it does not form a bond along its length with the concrete. Unbounded tendons are generally made of single strand high strength steel, covered with a corrosion inhibiting coating and encased i n a plastic sheathing. The force in the stressed tendon is transferred to the concrete primarily by the anchors provided at its ends. Variations in force along the tendon are affected by the friction between the strand and the tendon profile in the concrete member. Since the force in an unbounded tendon is transferred primarily by the anchor at its ends, the long term integrity of anchors throughout the service life of an unbounded tendon becomes crucial. The function of the plastic sheathing is (i) to act as a bond breaker, (ii) to provide protection against damage by mechanical handling and (iii) to form a barrier against intrusion of moisture and chemicals. The strand coating, commonly referred to as grease, (i) reduces friction between the strand and the plastic shealthing and (ii) provides added protection against corrosion.

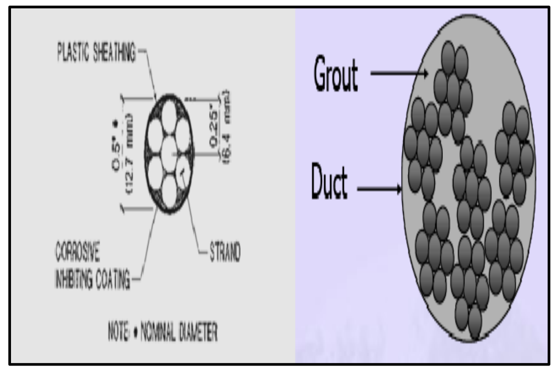


**Figure 2: cross section and dimensions of ½" (12.7 mm) 7-wire unbonded tendon**

## 2 Modeling and Analysis

Different long span beam consider for bonded and unbonded post-tension system analysis and design as shown below the complete analysis and design done in structural analysis tool ADAPT-PT BUILDER and also ETABS 2016 Design of Post-Tensioning and RCC Structural Systems". The results for the different long span beam are given here for different span length. Post tension beam analys is based on bonded and unbonded system. Data using analysis beam are 10m to 20m, also data give bending moment, shear force, deflection, mid top stress, mid bottom stress. And also give T- beam. All parameter give different between bonded and unbonded beam. Non pt-reinforce me not are define by the graphically with long span beam.

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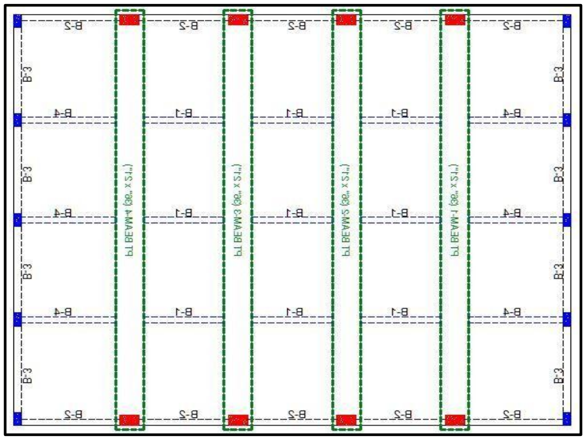

**Figure: 3 Plan of school hall**

**Table 1: Description of long span beam for Different Span Length**

| Description | Suggested value |
|---|---|
| Beam size | 600mm x 750mm |
| Dead load | 1.5 KN/m$^2$ |
| Live loading | 5 KN/m$^2$ |
| Column size | 500 mm x 500 mm |
| length | 10 m-20m |
| Slab thickness | 150mm |

## *2.1 Analysis of Beam*

The modeling of the long span beam in the structural analysis tool ADAPT-PT BUILDER. Analysis give the complete post-tensioned result bonded and unbonded system.

**Table 2: Deflection in long span beam for Different Span Length**

| | Deflection (mm | | | |
|---|---|---|---|---|
| Span(m) | Sustained load | | Service load | |
| | Bonded | Unbonded | Bonded | Unbonded |
| 10 | 0.39 | 0.32 | 0.42 | 0.39 |
| 12 | 1.36 | 1.04 | 2.4 | 2.04 |
| 14 | 4.09 | 3.69 | 5.91 | 5.46 |
| 16 | 8.65 | 8.08 | 11.66 | 11.1 |
| 18 | 15.28 | 14.7 | 20.2 | 19.49 |
| 20 | 24.87 | 24.02 | 31.79 | 30.94 |

Table shows Deflection of the beam with different span for sustained load and service load. Due to combination different value were obtained after analysis. Service load deflection more due to other combination. Also deflection in bonded and unbonded long span beam deflection variation very nearer up to ratio 1-3

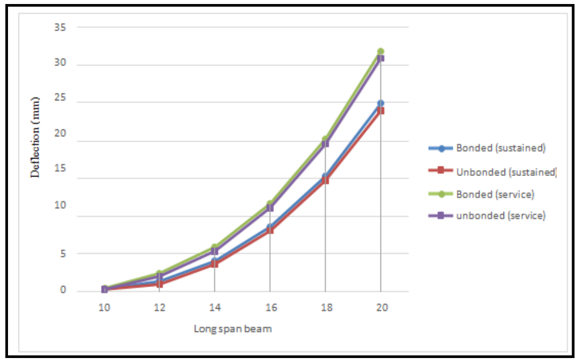


**Figure 4: long Span beam v/s Deflection**

The deflection in span 10-20 m up to 1-32 mm which is less than permissible limit (span/300) to satisfy the serviceability criteria. The deflection is within the permissible limits for all loading conditions for all considered span length of long span beam

**Table 3: Bending moment in long span beam for Different Span Length**

| | Bending Moment(N/mm$^2$) | | | |
|---|---|---|---|---|
| Span(m) | Sustained load | | Service load | |
| | Bonded | Unbonded | Bonded | Unbonded |
| 10 | 20.69 | 18.03 | 30.98 | 28.3 |
| 12 | 52.06 | 43.87 | 98.99 | 82.84 |
| 14 | 132.37 | 115.69 | 196.42 | 179.54 |
| 16 | 223.37 | 207.02 | 305.07 | 288.7 |
| 18 | 321.29 | 304.7 | 423.11 | 406.52 |
| 20 | 426.35 | 410.37 | 547.95 | 531.99 |

Table shows Bending moment of the beam with different span for sustained load and service load. Due to combination different value were obtained after analysis. Bending moment is change with span and also changes cable profile. Where is the variation between both systems 1- 3%.

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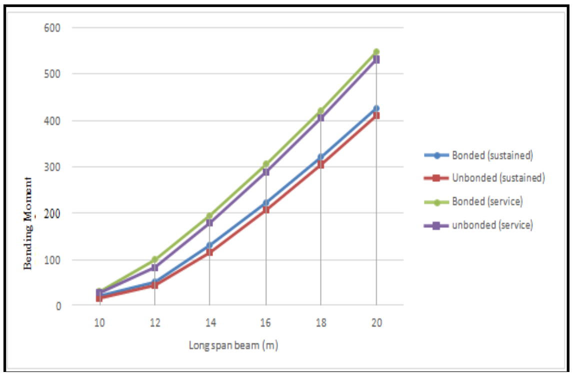


**Figure 5: long Span beam v/s Bending moment**

Bending moment show in figure the value bonded and unbonded increase with span and also nearer value. The long span beam applying load is same but bending moment is variance due to span different

**Table 4 Shear force in long span T-beam for Different Span Length**

| | Shear Force (KN | | | |
|---|---|---|---|---|
| Span(m) | Sustained load | | Service load | |
| | Bonded | Unbonded | Bonded | Unbonded |
| 10 | 19.75 | 18.25 | 31.76 | 26.65 |
| 12 | 45.76 | 41.73 | 64.13 | 60.1 |
| 14 | 71.57 | 68.33 | 93.35 | 90.11 |
| 16 | 98.25 | 95.79 | 123.74 | 121.35 |
| 18 | 119.54 | 117.46 | 148.49 | 146.33 |
| 20 | 140.06 | 138.26 | 172.58 | 170.58 |

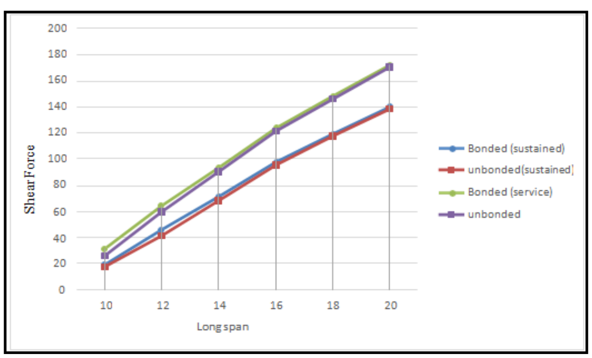


**Figure 6: long Span beam v/s Shear Force**

For Sheer force graph bonded and unbonded post-tensioning is increase due to span and both system difference ratio due up to 0.5-2%

**Table 5: Top stress in long span beam for Different Span Length**

| | Top stress ($N/mm^2$) | | | |
|---|---|---|---|---|
| Span(m) | Sustained load | | Service load | |
| | Bonded | Unbonded | Bonded | Unbonded |
| 10 | 1.59 | 1.29 | 2.46 | 2.41 |
| 12 | 2.88 | 2.42 | 3.72 | 3.41 |
| 14 | 4.32 | 4.02 | 5.46 | 5.16 |
| 16 | 5.94 | 5.62 | 7.39 | 7.1 |
| 18 | 7.7 | 7.4 | 9.51 | 9.21 |
| 20 | 9.57 | 9.28 | 11.73 | 11.45 |

Table shows top stress of the beam with different span for sustained load and service load. Due to combination different value were obtained after analysis. There is variation defer up to 1to5%. Top stress is effect on compression member beam. That effect create crack in beam. The top stress is consider base on IS 1343-1980 that code give permissible stress. Design of permissible compressive stress is given in code (IS: 1343-1980, 22.8, 22.8.1)

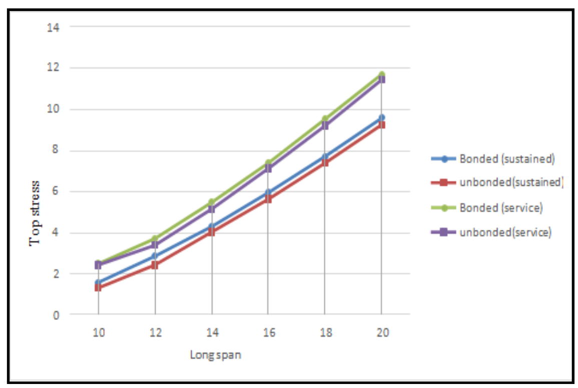


**Figure 7: long Span beam v/s Top stress**

Top stress in bonded and unbonded long span beam value suitable base on code. Suitable value is lower that kind of minimum value is consider

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**Table 6: Bottom stress in long span beam for Different Span Length**

| | Bottom stress ($N/mm^2$) | | | |
|---|---|---|---|---|
| Span(m) | Sustained load | | Service load | |
| | Bonded | Unbonded | Bonded | Unbonded |
| 10 | -1.55 | -1.75 | -1.35 | -1.33 |
| 12 | -0.99 | -1.11 | -0.19 | -0.47 |
| 14 | 0.39 | 0.99 | 1.52 | 1.23 |
| 16 | 2 | 1.71 | 3.46 | 3.17 |
| 18 | 3.73 | 3.43 | 5.54 | 5.24 |
| 20 | 5.59 | 5.31 | 7.75 | 7.47 |

Table shows bottom stress of the beam with different span for sustained load and service load. Due to combination different value were obtained after analysis. There is variation up to 2 to 5%. Bottom stress value consider based on (IS: 1343-1980, 22.7, 22.7.1) serviceability crate area is given. That Type-1, 2, 3 design create area for unfrocking section

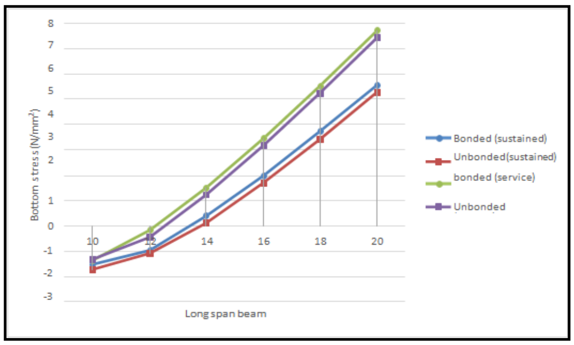


**Figure 8: long Span beam v/s Bottom stress**

## 3. CONCLUSIONS

In the present study an attempt was made to compare the different post tensioned systems with different span. The following conclusion has been derived based on comparative study done for the two methods of post tensioning different type of geometries having different span length

[1]. There is 2 to 10% reduction in deflection of unbonded beam in comparison with bonded beam.

[2]. Labor cost is more and steal quantity is less in case of bonded beam and vice versa in case of unbonded beam. Time required for casting of unbonded beam isless.

[3]. Also the long term stress generated is more in case of bonded beam and base on case study bonded anchoring is complicated compare to unbonded system.

[4]. On case study In bonded beam some extra length provided for anchoring system. But in unbonded beam anchoring provided on transverse direction beam

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